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(71) Applicant: SIEMENS INFORMATION AND COMMUNICATION MOBILE LLC [US/US]; 2205 Grand Avenue Parkway, Austin, TX 78728-3811 (US).

(72) Inventors: BERGER, H. Stephen; 140 River Road, Georgetown, TX 78628 (US). DUNCAN, Michael G.; 1802 Stamford Lane, Austin, TX 78703 (US). JACKSON, Andrew W.; 10104 Glencarrie Lane, Austin, TX 78750 (US).

(74) Agents: KIM, Rosa S. et al.; Siemens Corporation - Intellectual Property Dept., 186 Wood Ave. South, Iselin, NJ 08830 (US).

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(54) Title: SYSTEM AND METHOD FOR AVOIDING INTERFERENCE IN SPREAD SPECTRUM SYSTEMS

(57) Abstract: A system and method for avoiding interference in spread spectrum systems are disclosed. The system generally comprises a detector operable to detect interference from a co-located system operating in at least one of the same frequency bands as the system, an identifier operable to identify a transmission of the co-located system, and a transmission modifier operable to modify a transmission of the spread spectrum system to avoid substantial interference with the transmission of the co-located system.

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B. FIELDS SEARCHED

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 621 707 A (IBM) 26 October 1994 (1994-10-26)	1-4, 11-19, 21-24, 29-33, 35-37
Y	page 9, line 16 - line 31 page 10, line 5 -page 12, line 5 page 13, line 1 -page 14, line 21 claim 1	5-7,25

X	DE 34 15 032 A (SIEMENS AG) 8 November 1984 (1984-11-08)	1-4, 13-15, 17, 22-24,36
A	page 6, line 26 -page 8, line 29	11,12, 19,29

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 974 101 A (NAGO HIDETADA) 26 October 1999 (1999-10-26)	8-10,13, 18, 26-28, 31,34,38
Y	column 9, line 23 - line 45	5-7,25
X	DEMIRKIRAN I ET AL: "A knowledge-based interference rejection scheme for direct sequence spread-spectrum systems" PERSONAL WIRELESS COMMUNICATIONS, 1997 IEEE INTERNATIONAL CONFERENCE ON MUMBAI, INDIA 17-19 DEC. 1997, NEW YORK, NY, USA,IEEE, US, 17 December 1997 (1997-12-17), pages 120-124, XP010268051 ISBN: 0-7803-4298-4 abstract	1,22,36

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Information on patent family members

Inte. ational Application No
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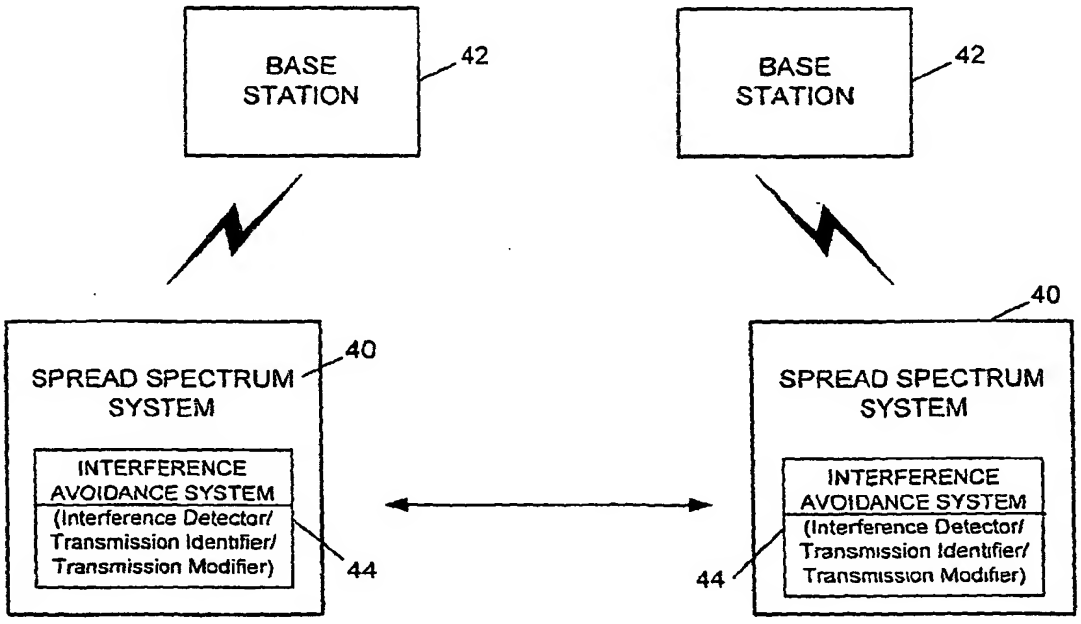
(54) Title: SYSTEM AND METHOD FOR AVOIDING INTERFERENCE IN SPREAD SPECTRUM SYSTEMS



(57) Abstract: A system and method for avoiding interference in spread spectrum systems are disclosed. The system generally comprises a detector operable to detect interference from a co-located system operating in at least one of the same frequency bands as the system, an identifier operable to identify a transmission of the co-located system, and a transmission modifier operable to modify a transmission of the spread spectrum system to avoid substantial interference with the transmission of the co-located system.

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SYSTEM AND METHOD FOR AVOIDING INTERFERENCE IN SPREAD SPECTRUM SYSTEMS

FIELD OF THE INVENTION

The present invention relates generally to communication systems, and more specifically, to a system and method for avoiding interference in spread spectrum systems.

BACKGROUND OF THE INVENTION

Several frequency bands allow for the operation of various kinds of dissimilar equipment. Any equipment that meets the minimum operational requirements of the band may use these bands. An example is the 2.4 GHz ISM (Industrial, Scientific, and Medical) band, where any system that meets the requirements of the band may operate. The FCC allows users to operate wireless products within these bands without obtaining FCC licenses if the products meet certain requirements, such as operation under one watt transmitter output. Because these bands are "free", they are often heavily polluted by other unlicensed systems. Several wireless network types, cordless phones, and other types of equipment utilize these bands, which are becoming increasingly crowded. The 2.4 GHz band also suffers from microwave oven radiation interference.

When these systems are in close proximity their transmissions often overlap and interfere with each other. The result is a degradation of performance. Moreover, when systems interfere the situation is often exacerbated because the systems must increase their transmission frequency in order to retry packets that were not successfully transmitted. This only increases the number of transmission collisions.

Many types of equipment provide no interference protection at all. Those that do have interference protection typically identify frequencies which are being used and avoid them in their frequency hopping. The FCC allows spread spectrum systems to operate unlicensed in certain frequency bands, such as the 2.4 GHz ISM band. These systems often have to contend with interference from other spread spectrum systems and also from other sources. Spread spectrum systems such as frequency hoping (FH) or direct sequence (DS) dynamically change their transmission frequency and cannot avoid mutual interference using a fixed frequency map.

There is, therefore, a need for a system and method for avoiding interference to and between spread spectrum systems.

SUMMARY OF THE INVENTION

A system and method for avoiding interference in spread spectrum systems are disclosed. In one embodiment, a system generally comprises a detector operable to detect interference from a co-located system operating in at least one of the same frequency bands as the system, an identifier operable to

identify a transmission of the co-located system, and a transmission modifier operable to modify transmission of the spread spectrum system to avoid substantial interference with the transmission of the co-located system.

The spread spectrum system may be a frequency hopping or direct sequence spread spectrum system, for example. The system may be configured to detect other frequency hopping or direct sequence systems, or other transmitting devices such as a microwave oven.

A method for avoiding interference in spread spectrum systems generally comprises detecting a co-located system operating in at least one of the same frequency bands as the spread spectrum system and identifying a transmission of a co-located system. The method further includes modifying a transmission of the spread spectrum system to avoid substantial interference with the co-located system.

The above is a brief description of some deficiencies in the prior art and advantages of the present invention. Other features, advantages, and embodiments of the invention will be apparent to those skilled in the art from the following description, drawings, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A, 1B, and 1C illustrate transmission over a direct sequence spread spectrum system.

Fig. 2 illustrates transmission over a frequency hopping spread spectrum system.

Fig. 3 is a block diagram illustrating two co-located spread spectrum systems.

Fig. 4 is a schematic illustrating two co-located wireless LANs.

Fig. 5 is a block diagram illustrating a plurality of co-located spread spectrum systems and a microwave oven.

Fig. 6 is a schematic illustrating a mobile phone co-located with a spread spectrum system.

Fig. 7 is a flowchart illustrating a process for identifying interference at a WDCT system from a co-located device and adjusting a signal to avoid interference with the co-located device.

Fig. 8 is a flowchart illustrating a process for identifying interference from at a direct sequence spread spectrum system and adjusting a signal to avoid interference with the direct sequence spread spectrum system.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION OF THE INVENTION

The following description is presented to enable one of ordinary skill in the art to make and use the invention. Descriptions of specific embodiments and applications are provided only as examples and various modifications will be readily apparent to those skilled in the art. The general principles described

herein may be applied to other embodiments and applications without departing from the scope of the invention. Thus, the present invention is not to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features described herein. For purpose of clarity, details relating to technical material that is known in the technical fields related to the invention have not been described in detail.

Equipment such as wireless LAN products frequently employ some type of spread spectrum technique to communicate between fixed and mobile stations and network access points. The basic operation of a spread spectrum communication system is to take an information signal and spread it in frequency until it occupies a much larger bandwidth than the original information signal. The two most common spread spectrum modulation techniques used in systems such as wireless LAN are frequency hopping (FH) spread spectrum and direct sequence (DS) spread spectrum. The direct sequence system produces a continuous noise-like signal which contains energy at all frequencies in the spread bandwidth, whereas the frequency hopping system produces a burst signal on discrete frequencies within this band. Figs. 1A-C and 2 illustrate transmission of signals via direct sequence and frequency hopping spread spectrum systems, respectively.

As shown in Figs. 1A, 1B, and 1C, direct sequence spreads a signal 20 on a larger band 22 by multiplexing it with a signature (code) to minimize localized interference and background noise. The system works over a fixed large channel. DS spread spectrum combines a data signal at the sending station with a higher data rate bit sequence, which is often referred to as a chipping code or processing

gain and sends a specific string of bits for each data bit sent (Fig 1A). As the data stream is transmitted, the corresponding code is sent. To spread the signal, each bit of the packet to transmit is modulated by a code (Fig 1B). In the receiver, the original signal is recovered by receiving the whole spread channel (averaging effect) and demodulating by the same code. At the receiving end, the spread spectrum signal 22 is despread to generate the original narrowband signal 20 (Fig. 1C).

Frequency hopping uses a set of narrow channels and walks through all of them in sequence. For example, the 2.4 GHz ISM band is divided into 79 channels of 1 MHz. Periodically (e.g., every 20 to 400 ms), the system hops to a new channel, following a predetermined cyclic hopping pattern (Fig. 2). FCC regulations require manufacturers to use 75 or more frequencies per transmission channel with a maximum dwell time (i.e., time spent at a particular frequency during any single hop) of 400 ms in ISM bands. FH takes the data signal and modulates it with a carrier signal that hops from frequency to frequency as a function of time over a wide band of frequencies. With FH, the carrier frequency is periodically modified (hopped) following a specific spreading code. The spreading (hopping) code determines the frequencies that the device will transmit and in which order. To properly receive the signal, the receiver must be set to the same hopping code and listen to the incoming signal at the right time and correct frequency. If a channel is bad, the system might not be able to use it and just waits for the next good channel. Frequency hopping may loose bad hops 30 but will manage to get good hops 32 on good frequencies (see Fig. 2).

The system of the present invention utilizes identification algorithms to identify co-located systems and then adjusts the transmission pattern to avoid mutual interference. The term co-located as used herein means that a device is within a transmission range of another possibly interfering device. The co-located systems are non-fixed frequency devices such as the frequency hopping or direct sequence spread spectrum systems described above. It is to be understood that the systems may utilize non-fixed frequency transmissions other than the spread spectrum transmission described herein.

Fig. 3 illustrates two co-located spread spectrum devices 40 each in communication with a base station 42. Each device 40 includes an interference avoidance system 44 which comprises an interference detector, transmission identifier and transmission modifier 44. When interference is detected at either one of the devices 40, the interference avoidance system 44 performs a transmission identification process to identify the transmission protocol being used by the other co-located device which is interfering with its own transmission. Once identified, a non-interfering or minimal interfering transmission pattern is selected for use by the device 40 that detected the interference. If the transmission quality is still not acceptable, the identification process is once again performed to see if there are additional co-located systems operating or if the co-located system has changed its transmission pattern. It is to be understood that only one device 40 may include the interference avoidance system 44 if there are only two co-located interfering systems. In the case of multiple co-located systems, each system may include the interference avoidance system 44. Also, a single interference avoidance system 44 may be used to

modify the transmission of multiple wireless devices, as described below. The interference avoidance system 44 may be a single device or multiple devices, each performing one or more of the functions of the system. Such a system may be integrated into a common wireless LAN system, such as a Home RF, IEEE802.11 or Bluetooth system, or a cordless phone system, such as a WDCT system. The system is preferably implemented in the operating software and functions as an integrated part of a host unit.

Fig. 4 illustrates two co-located wireless LAN (Local Area Network) systems 50, 52. Each system 50, 52 includes a plurality of network devices 54 each having a NIC (Network Interface Card) which interfaces the device with the wireless network through an access point (bridge) 56. The access point 56 interfaces the wireless network with a wired network. The access point 56 and each device 54 preferably include the interference avoidance system 44. The two systems 50, 52 may, for example, both use the same transmission standard (e.g., both utilize DS or both utilize FH). In this case, the two LAN systems 50, 52 are sufficiently similar so that the transmission can be decoded and identified, as further described below. The interference avoidance system 44 allows each LAN to identify the other's transmission and identify the type of system with a single transmission. The process for identifying systems utilizing different transmission standards is described below with reference to Fig. 5.

Fig. 5 illustrates two FH systems 70, one DS system 72, and a microwave oven 74 which are all co-located. Each FH and DS system 70, 72 includes the interference avoidance system 44 which is used to identify interfering systems and modify the system's own transmission to prevent or reduce interference by

the interfering system. The FH systems 70 may identify the other FH system by identifying the transmission's hopping pattern. In one scenario, the FH systems 70 may be similar and use the same channel. For example, HomeRF systems typically utilize a fixed hopping pattern. Separate, co-located Home RF systems are thus only differentiated by their timing in the hopping pattern. A single channel can therefore be monitored. The hopping sequence is determined once a transmission is detected. This same method can be used for any FH system 70 using a known, fixed hopping pattern.

In another scenario, the FH systems 70 are different and do not utilize the same channel pattern. For example, HomeRF typically uses 1 MHz channel centers and WDCT (Worldwide Digital Cordless Telecommunications (see below)) typically uses .843 MHz channel centers. In this case, approximately every fifth channel provides a close overlap. Thus, the WDCT system 70 can identify the Home RF system by looking for a transmission on every fifth step in the hopping pattern.

The transmission identifier 44 may also look for a timed pattern or known time sequence of a transmission to identify a co-located system. For example, microwave ovens 74 and other similar transmitters utilize the same frequencies on a periodic basis. Microwave ovens 74 commonly operate on a 60 Hz rate but only transmit for a portion of each cycle. The microwave's use of frequency also varies over its transmission. The microwave 74 tends to emit a very broad signal at first and narrow the frequency range used as the transmission continues. By monitoring this behavior, a pattern can be identified to determine when the

affected channels are available in the 60 Hz cycle. The FH system 70 then knows which time slots are available within a frequency band for the FH system to use.

The DS system 72 identifies the FH system 70 by a time sequence pattern of transmissions in each DS frequency band. DS systems 72 are typically not equipped with filters that allow the system to monitor individual FH channels 74. However, similar to the method described above, a DS system 72 may monitor the timing of interfering transmissions. The FH system 70 may therefore be identified by the appearance of the FH system's transmission timing pattern within the bandwidth of the DS system 72.

Once a co-located system is identified, a non-interfering transmission pattern is selected. One option for two co-located FH systems 70 is to coordinate the FH systems by selecting an orthogonal hopping sequence. The orthogonal sequence prevents the simultaneous transmission on a given channel of the co-located devices to minimize the number of transmission collisions. A set of hopping codes that do not use the same frequencies at the same time are considered orthogonal. For example, a set of orthogonal frequency hopping sequences is any set of N channel frequencies to N communication links such that no two links use the same channel at the same time and the assignment of channel to link changes periodically for all links at the same instant.

An alternative approach is to coordinate the timing of transmissions to avoid interference. For example, if microwave oven 74 is operating on a 60 Hz cycle but operating only during a portion of the cycle is, transmissions on the channels shared with the microwave are timed such that they only occur during the open period not being used by the microwave.

Similarly, the transmission of FH and DS systems 70, 72 can be coordinated. If an FH hopping pattern is planned so as to assure a DS system certain open periods in its bandwidth, then the DS system can adjust its transmission pattern to utilize this periodicity in its transmission band.

In the case of multiple co-located systems, as shown in Fig. 5, the pattern of each system 70, 72, 74 is identified and a transmission pattern which minimizes interference with the combination of co-located systems is selected. In the case of several co-located systems 70, 72, 74, it is unlikely that all of the systems interfere with the same signal strength. Thus, some weighting may be provided which first accounts for the system with the highest interference potential and then adjusted for systems of weaker interference.

Fig. 6 illustrates a mobile phone 80 and a co-located spread spectrum system 82. The mobile phone 80 may operate based on a platform such as WDCT (Worldwide Digital Cordless Telecommunications), for example. WDCT is a derivative of the European Digital Enhanced Cordless Telecommunications (DECT) standard. The interference avoidance function is preferably performed for the mobile phone 80 only if transmission quality falls below a predetermined level. This avoids adding to the system operating overhead until there is a problem with transmission quality. The interference avoidance system 84 may be located within the handset 80, base station 42, or separate device in communication with the mobile phone (as shown in Fig. 6). If an improved transmission pattern is identified, the monitoring device 84 reports it to the mobile phone 80 so that the phone can change its transmission to the improved transmission without an interruption in service. The interference avoidance

system 84 may be located within a mobile device such as a wireless phone handset and may be configured to send information about the identified interfering transmission to more than one wireless device.

The interference avoidance system 44 is preferably dynamic to accommodate co-located systems being turned on or off. Also, mobile units may be passing by other systems and intermittently causing interference. In order to make the system 44 more efficient, a history of successful transmission patterns is preferably stored. These stored patterns are used to identify other co-located systems as they interfere with the transmission from the device. New patterns are developed if the previously identified patterns fail to provide the desired transmission quality.

The system and method of the present invention may be used with different FH systems that use hopping patterns that are easily identified and which provide additional choices for orthogonal patterns. FH system patterns may be selected to assist DS systems in selecting a non-interfering transmission by allowing more contiguous open time in each possible DS transmission band. The FH system may also be configured so as to use a pattern that is more easily identified by a monitoring DS system. The system 44 may also include a pattern recognition algorithm. For example, the system 44 may be enhanced by the addition of an algorithm that monitors the transmissions and identifies a pattern over time. The system 44 would thus, become more effective over time. These implementations may be used in systems which are planned to be co-located.

Fig. 7 is a flowchart illustrating a process for interference avoidance in a WDCT system. If the transmission quality drops below a predetermined level

(step 100) the system first determines if there is a record of previous interference sequences which have been successful (step 102). These are preferably tried before a new monitor and analysis sequence is initiated (steps 104 and 106). If prior history is not available or does not resolve the problem, the system then looks at the interfering signals to see if it can decode the transmission and identify the transmitter type. If the interfering transmission is from a similar system, the device will most likely recognize the other's signal (step 108). Once the type of system is known, an orthogonal transmission pattern is selected (step 110). The orthogonal transmission pattern eliminates or minimizes transmission interference between the co-located systems.

If the systems are not similar and decoding cannot be used to identify the transmission, the hopping sequence is analyzed (step 112). This is accomplished by monitoring a channel until a transmission is detected. If the transmission pattern matches a known hopping sequence, the system is identified and the device's transmission is modified to match a pattern that is orthogonal to the interfering signal (step 114). If a hopping pattern is not identified, the system attempts to identify a timing of the interfering signal (step 116). If the timing pattern is identified, the transmission's timing is modified to reduce or eliminate interference. For example, if the interfering signal is from a microwave 74, the system's signal is modified to occur on the affected channels at times when the microwave's transmission does not interfere (step 118).

If the system still has not identified the signal and there is only one co-located system, the best identified pattern is used (steps 120 and 122). If multiple systems are present, the device attempts to identify the transmission of the other

systems and an orthogonal pattern that provides minimal interference is selected (steps 120 and 124). The implementation for multiple systems first identifies one co-located system and adjusts for it. If the transmission quality is still not acceptable, the system looks for a second co-located system. For example, an FH system 70 may use a hopping pattern that is orthogonal to another FH system and utilize channels in the microwave's transmission band only during the unused periods of the microwave's 60 Hz cycle. The above process is repeated anytime the transmission quality of the device falls below unacceptable level.

A second example illustrated in the flowchart of Fig. 8 is a system implemented in a DS system for monitoring a broad frequency section of a transmission band. The monitoring is preferably initiated only when transmission quality is unacceptable (step 150). The prior history is first checked and the system attempts to decode the transmission if from a similar system (steps 152–160), as previously described. If the above steps fail to achieve sufficient transmission quality, the system monitors its frequency band since the FH system transmits on multiple channels within the area of frequency being monitored. The system looks for a pattern in the timing of the transmission rather than a pattern in the frequency of the transmission (steps 162). For example, a fixed pattern (such as provided by a HomeRF transmission) will produce a repetitive pattern in a given frequency area. Once the pattern is identified the device's transmission is modified to reduce interference (step 164). If multiple systems are present, the device attempts to identify the transmission of the other systems and an orthogonal pattern that provides minimal interference is selected (steps 166 and 170).

As can be observed from the foregoing, the system and method of the present invention provide numerous advantages over conventional systems. The system identifies co-located non-fixed frequency systems and then adjusts the transmission pattern to avoid mutual interference, thus allowing two or more co-located systems to operate simultaneously without significant interference.

Although the present invention has been described in accordance with the embodiments shown, one of ordinary skill in the art will readily recognize that there could be variations made to the embodiments without departing from the scope of the present invention. Accordingly, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

CLAIMS

1. A system for avoiding interference in a spread spectrum system, comprising:

a detector (44) operable to detect interference from a co-located system (40) operating in at least one of the same frequency bands as the system;

an identifier (44) operable to identify a transmission of the co-located system; and

a transmission modifier (44) operable to modify a transmission of the spread spectrum system to avoid substantial interference with the transmission of the co-located system.

2. The system of claim 1 wherein the system is a frequency hopping spread spectrum system (70).

3. The system of claim 2 wherein the detector (44) is operable to detect a spread spectrum system (72).

4. The system of claim 3 wherein the detector (44) is operable to detect a frequency hopping spread spectrum system.

5. The system of claim 1 wherein the system is a direct sequence spread spectrum system (72).

6. The system of claim 5 wherein the detector (44) is operable to detect a spread spectrum system.

7. The system of claim 6 wherein the detector (44) is operable to detect a frequency hopping system (70).

8. The system of claim 1 wherein the detector (44) is operable to detect a microwave oven (74).

9. The system of claim 8 wherein the identifier (44) is operable to identify unused time slots.

10. The system of claim 9 wherein the transmission modifier (44) is operable to adjust the transmission of the spread spectrum system to utilize the unused time slots.

11. The system of claim 1 wherein the transmission modifier (44) is configured to store identified transmission patterns.

12. The system of claim 11 wherein the transmission modifier (44) first tries to match the stored identified transmission patterns to the transmission of the co-located system when the detector detects the co-located system.

13. The system of claim 1 wherein the detector (44) is configured to detect a co-located system when interference degrades transmission quality below a predetermined level.

14. The system of claim 1 wherein the identifier (44) is configured to identify a co-located system by its hopping pattern.

15. The system of claim 14 wherein the identifier (44) monitors only one channel of the co-located system when the detected system has a fixed hopping pattern.

16. The system of claim 14 wherein the identifier (44) is configured to look for transmission on a fixed number of steps within the hopping pattern.

17. The system of claim 1 wherein the identifier (44) is configured to look for a timed pattern of transmission.

18. The system of claim 1 wherein the transmission modifier (44) is configured to select a hopping sequence that is orthogonal to the identified transmission of the co-located system.

19. The system of claim 1 wherein the transmission modifier (44) is operable to coordinate timing of transmissions to avoid interference.

20. The system of claim 1 wherein the system is a direct sequence spread spectrum system (72) and the transmission modifier (44) is operable to adjust its transmission pattern to utilize open periods identified in a frequency hopping co-located system (70).

21. The system of claim 1 wherein the detector (44) is operable to detect multiple co-located systems.

22. A method for avoiding interference in a spread spectrum system, comprising:

detecting a co-located system (40) operating in at least one of the same frequency bands as the spread spectrum system;

identifying a transmission of the co-located system; and

modifying a transmission of the spread spectrum system to avoid substantial interference with the transmission of the co-located system.

23. The method of claim 22 wherein detecting a co-located system comprises detecting a spread spectrum system.

24. The method of claim 23 wherein detecting a co-located system comprises detecting a frequency hopping spread spectrum system (70).

25. The method of claim 23 wherein detecting a co-located system comprises detecting a direct sequence spread spectrum system (72).

26. The method of claim 22 wherein detecting a co-located system comprises detecting a microwave oven (74).

27. The method of claim 26 wherein identifying a transmission pattern comprises identifying unused time slots.

28. The method of claim 27 wherein modifying a transmission pattern comprises adjusting the spread spectrum system's transmission to utilize the unused time slots.

29. The method of claim 22 further comprising storing previous identified transmission patterns.

30. The method of claim 29 further comprising using one of the previous identified transmission patterns when the detector detects a co-located system.

31. The method of claim 22 wherein detecting a co-located system comprises detecting the co-located system when interference degrades transmission quality of the system below a predetermined level.

32. The method of claim 22 wherein identifying a transmission pattern of the co-located system comprises identifying the co-located system by its hopping pattern.

33. The method of claim 22 wherein modifying a transmission pattern of the system comprises selecting a pattern that is orthogonal to the identified transmission pattern.

34. The method of claim 22 wherein the system is a direct sequence spread spectrum system (72) and modifying a transmission comprises adjusting the transmission of the direct sequence system to utilize open periods identified in a frequency hopping co-located system (70).

35. The method of claim 22 wherein detecting a co-located system comprises detecting multiple co-located systems.

36. A method for avoiding interference from a non-fixed frequency transmitting device, comprising:

detecting interference from the non-fixed frequency transmitting device (40);

identifying a transmission pattern of the transmitting device; and

modifying a transmission pattern of a device receiving the interference to substantially avoid interference with the non-fixed frequency transmitting device.

37. The method of claim 36 wherein modifying a transmission pattern comprises selecting a pattern that is orthogonal to the identified transmission pattern.

38. The method of claim 36 wherein modifying a transmission pattern comprises adjusting the transmission to utilize open periods in the identified transmission pattern.

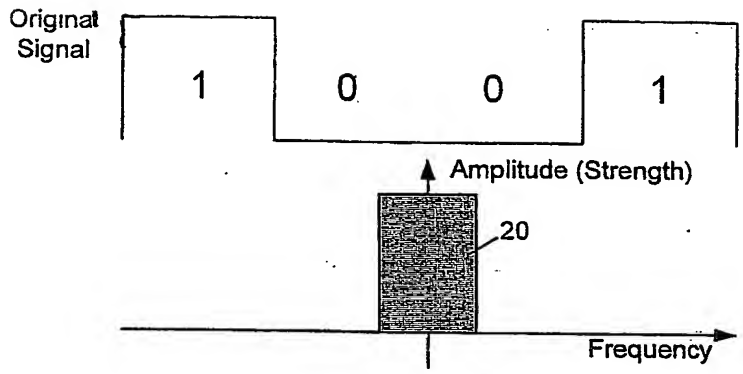

Fig. 1A

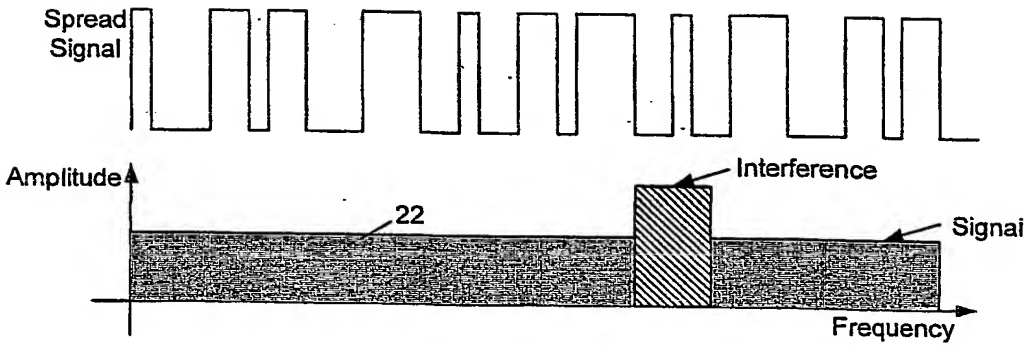

Fig. 1B

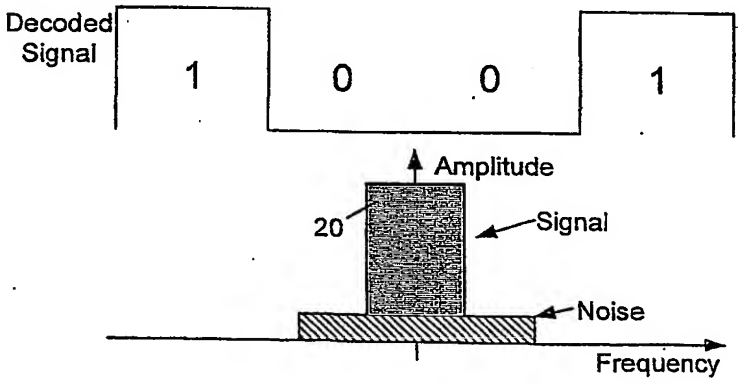

Fig. 1C

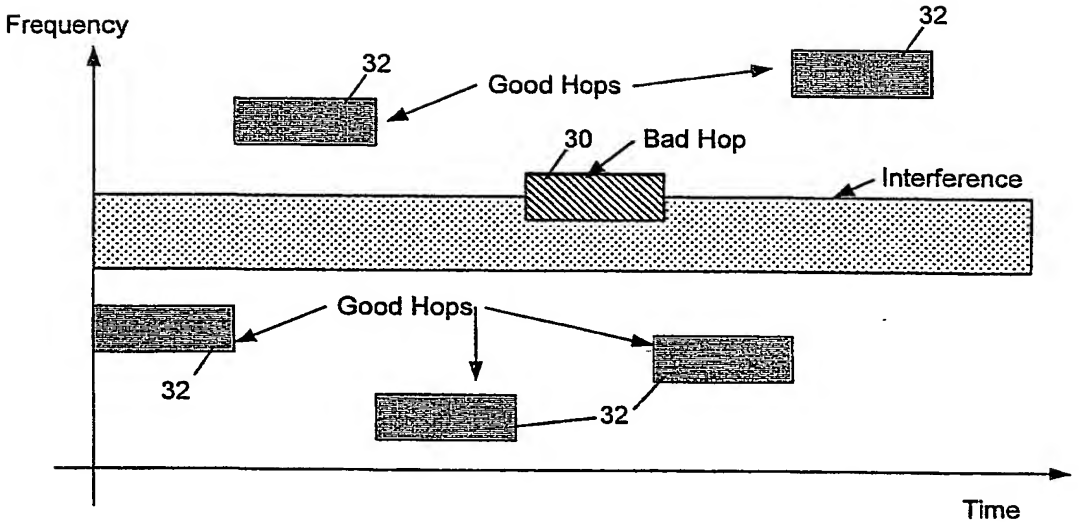
Frequency
32
Good Hops
32
30
Bad Hop
Interference
Good Hops
32
32
Time

Fig. 2

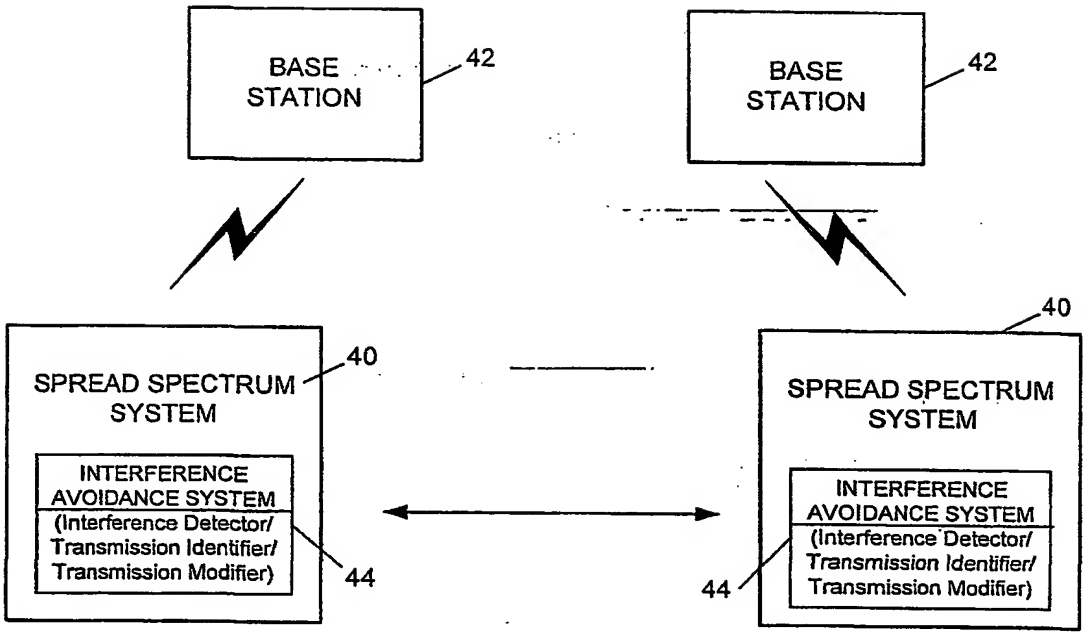
BASE STATION
42
BASE STATION
42
SPREAD SPECTRUM SYSTEM
40
INTERFERENCE AVOIDANCE SYSTEM
(Interference Detector/ Transmission Identifier/ Transmission Modifier)
44
SPREAD SPECTRUM SYSTEM
40
INTERFERENCE AVOIDANCE SYSTEM
(Interference Detector/ Transmission Identifier/ Transmission Modifier)
44

Fig. 3

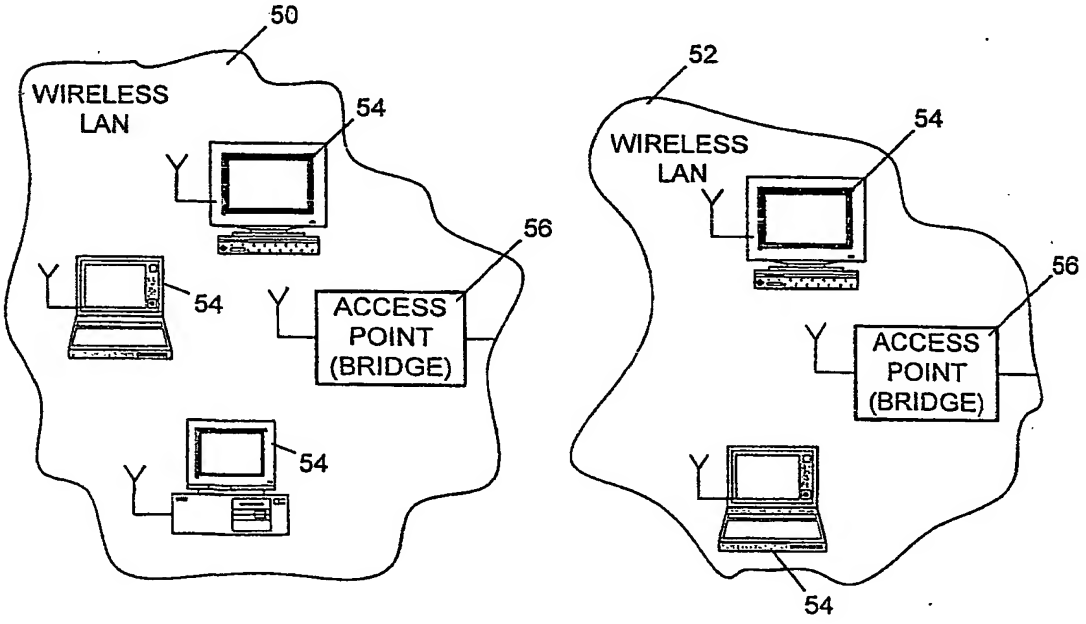
50
WIRELESS LAN
54
54
54
56
ACCESS POINT (BRIDGE)
52
WIRELESS LAN
54
56
ACCESS POINT (BRIDGE)
54

Fig. 4

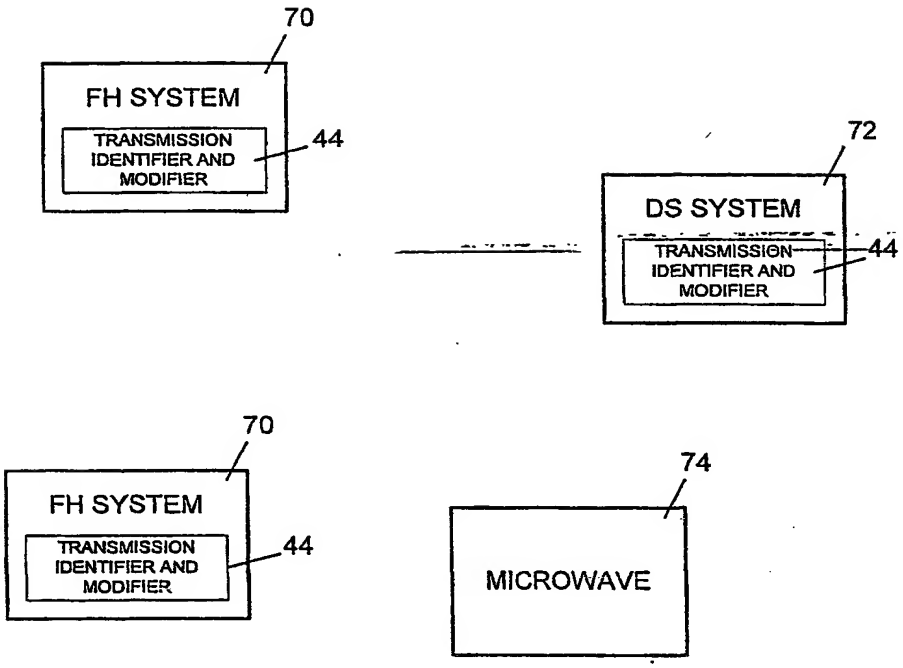
70
FH SYSTEM
TRANSMISSION IDENTIFIER AND MODIFIER
44
72
DS SYSTEM
TRANSMISSION IDENTIFIER AND MODIFIER
44
70
FH SYSTEM
TRANSMISSION IDENTIFIER AND MODIFIER
44
74
MICROWAVE

Fig. 5

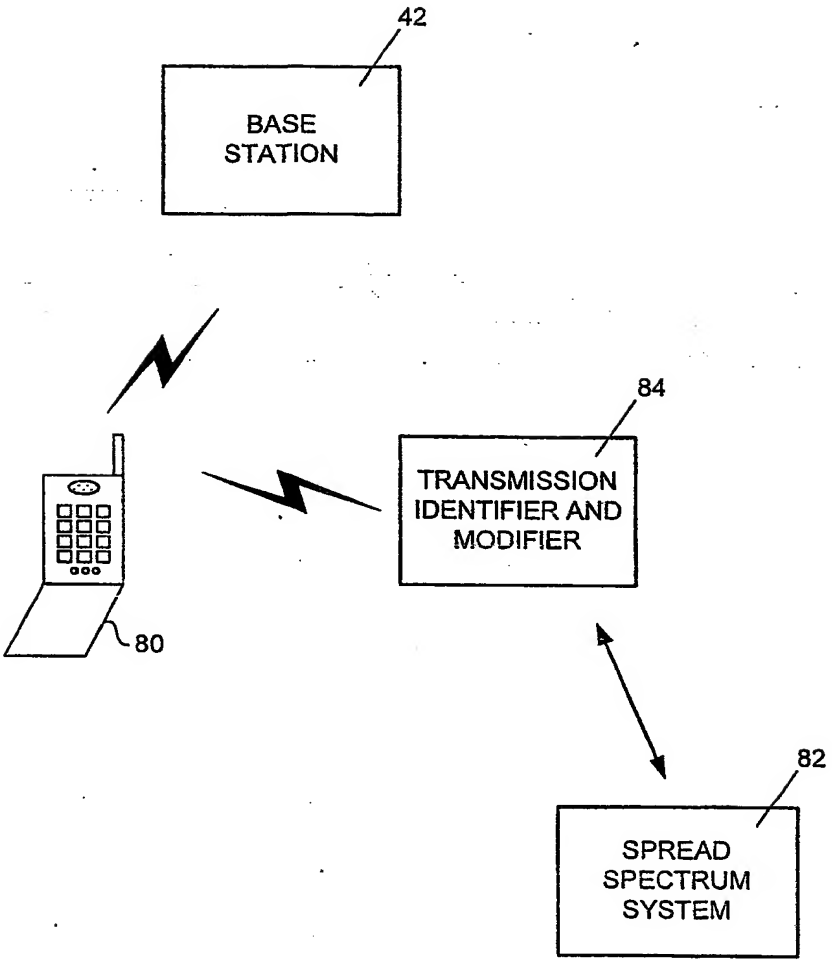
42
BASE STATION
84
TRANSMISSION IDENTIFIER AND MODIFIER
80
82
SPREAD SPECTRUM SYSTEM

Fig. 6

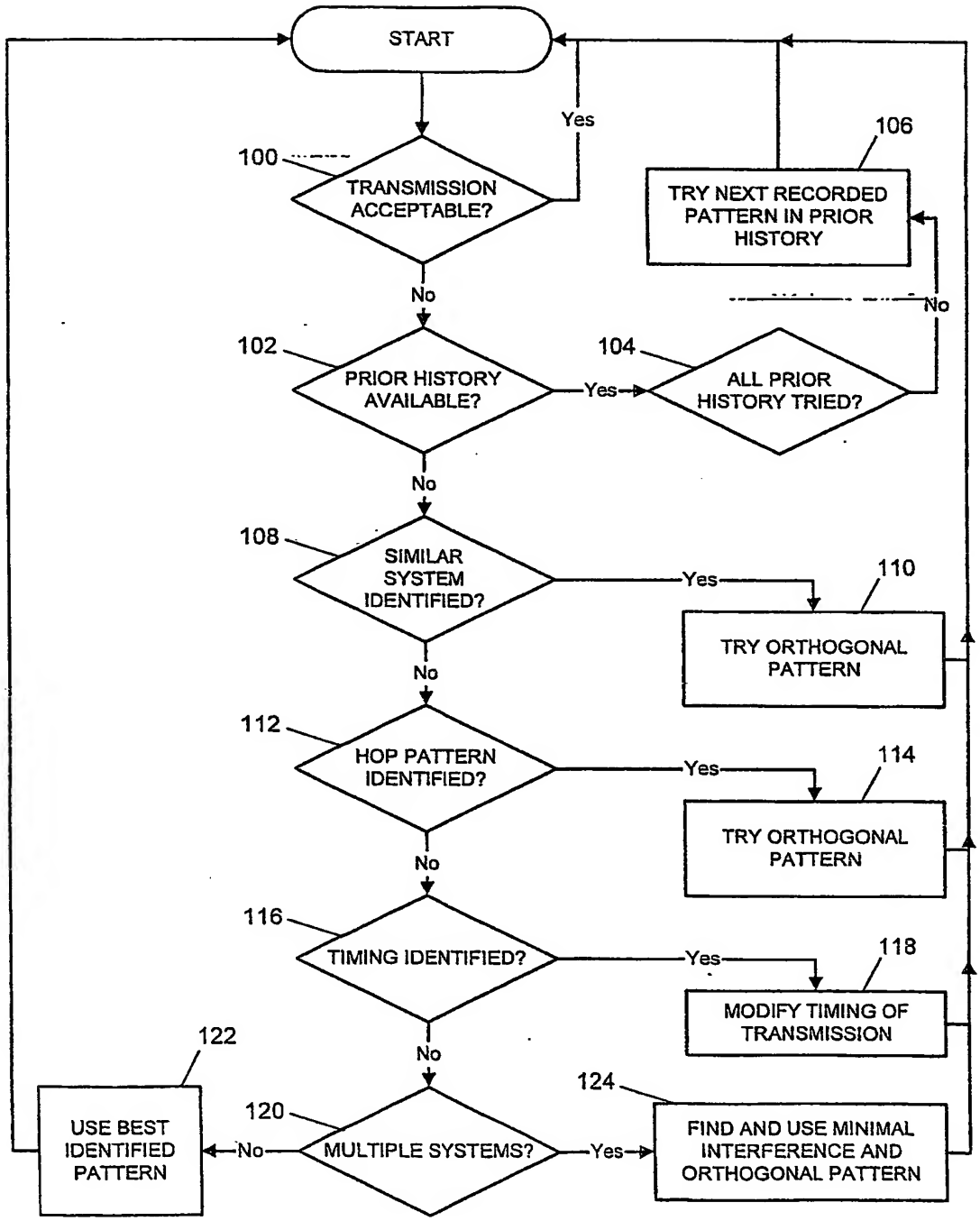
START
100
TRANSMISSION ACCEPTABLE?
Yes
No
106
TRY NEXT RECORDED PATTERN IN PRIOR HISTORY
No
102
PRIOR HISTORY AVAILABLE?
Yes
104
ALL PRIOR HISTORY TRIED?
No
108
SIMILAR SYSTEM IDENTIFIED?
Yes
110
TRY ORTHOGONAL PATTERN
No
112
HOP PATTERN IDENTIFIED?
Yes
114
TRY ORTHOGONAL PATTERN
No
116
TIMING IDENTIFIED?
Yes
118
MODIFY TIMING OF TRANSMISSION
No
122
USE BEST IDENTIFIED PATTERN
120
No
MULTIPLE SYSTEMS?
Yes
124
FIND AND USE MINIMAL INTERFERENCE AND ORTHOGONAL PATTERN

Fig. 7

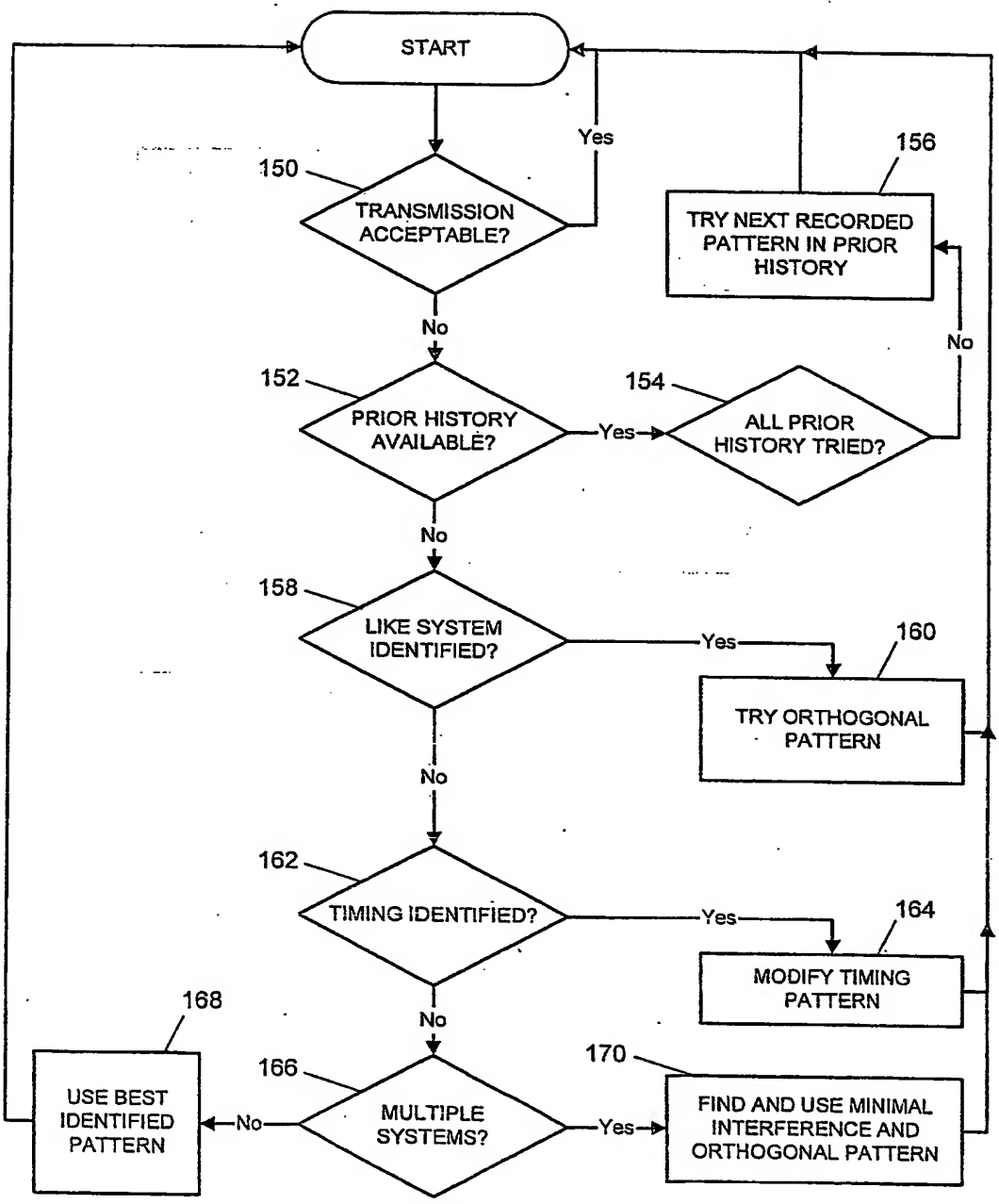
START
150
TRANSMISSION ACCEPTABLE?
Yes
No
156
TRY NEXT RECORDED PATTERN IN PRIOR HISTORY
No
152
PRIOR HISTORY AVAILABLE?
Yes
154
ALL PRIOR HISTORY TRIED?
No
158
LIKE SYSTEM IDENTIFIED?
Yes
160
TRY ORTHOGONAL PATTERN
No
162
TIMING IDENTIFIED?
Yes
164
MODIFY TIMING PATTERN
No
168
USE BEST IDENTIFIED PATTERN
166
MULTIPLE SYSTEMS?
No
Yes
170
FIND AND USE MINIMAL INTERFERENCE AND ORTHOGONAL PATTERN

Fig. 8

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